Orientation and distribution of recent gullies in the southern hemisphere of Mars: observations from HRSC/MEX and MOC/MGS data

Conference or Workshop Item

ORIENTATION AND DISTRIBUTION OF RECENT GULLIES IN THE SOUTHERN HEMISPHERE OF MARS: OBSERVATIONS FROM HRSC/MEX AND MOC/MGS DATA. M. Balme[1]*, N. Mangold[1], D. Baratoux[2], F. Costard[1], M. Gosselin[1], P. Masson[1], P. Pinet[2], G. Neukum & the HRSC CoI team[3]. [1] Laboratoire IDES, UMR 8148 CNRS & Univ. Paris-Sud, 91405 Orsay Cedex, France. [2] Laboratoire Dynamique Terrestre et Planétaire, 14, Avenue Edouard Belin, 31000 Toulouse, France, [3] Freie Universität Berlin, Institut für Geologie, Geophysik und Geoinformatik, Malteserstr. 74-100, D-12249 Berlin, Germany. * now at Dept. of Earth Sciences, Open University, Walton Hall, Milton Keynes , United Kingdom, MK7 6AA. m.r.balme@open.ac.uk; mattbalme@yahoo.com

Introduction: Small gullies on Mars (**fig 1**), first observed in Mars Global Surveyor (MGS) Mars Orbiter Camera Narrow Angle (MOC NA) images, are geologically recent and display a distinct "alcove channel debris apron" morphology consistent with erosion by water or debris flows with significant water content [1]. Suggested formation models are divided into two main categories: discharge of water from deep or shallow aquifers [e.g. 1,2,3] or near-surface ice/snow melting driven by climate change [e.g. 4,5]. The key question is whether gullies reflect an active subsurface hydrogeological cycle or concentration of volatiles from the atmosphere. To answer this requires analysis of the factors that control gully distribution and orientation. For a subsurface source model these might be regional topography, geology and elevation. For an atmospheric model, climate (e.g. local insolation, temperature and possibly humidity), would dominate, with orientation and distribution of gullies probably being strongly latitude dependent.

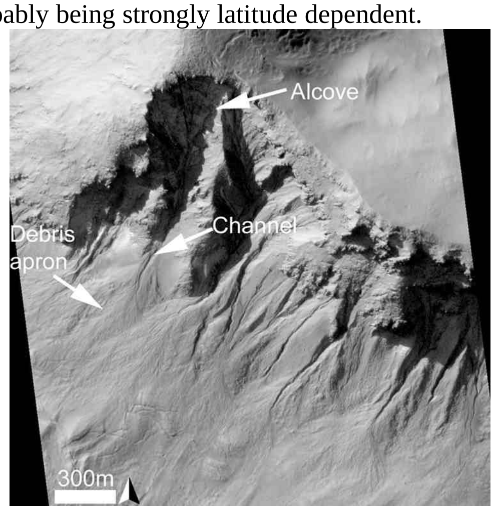

Fig.1 Examples of gullies (MOC NA image R0200691)

Approach: The aim of this work was to provide a high-quality dataset of orientation and distribution of gullies on Mars to test models of formation. The study area used was the southern hemisphere, from –10 ° to –80°. Both MOC NA (high resolution, low spatial coverage) and Mars Express High Resolution Stereo Camera (HRSC; medium resolution, very high spatial coverage) images were used to remove possible targeting biases that might occur with a solely MOC NA study, and to allow measurements of gully length without truncation of the observed gullies..

More than 22,000 MOC NA and 120 HRSC images were examined. Discrete gullied slope sections with consistent orientation were recorded rather than individual gullies. Local context, geographical location, orientation and mean gully length (HRSC only) were recorded for each slope section. In the MOC survey, more than 900 distinct gullied slope sections were found. More than 380 distinct gullied slope sections were identified using HRSC.

Results: In both MOC and HRSC data, gullies are most common between –30 and –50 degrees latitude (**fig 2**) and overall have a strong pole-facing preference (**fig 3**). For HRSC, the mode is SE rather than S. Higher latitude gullies show less preference for pole facing than those at mid latitudes (**fig 4**). Impact crater inner walls are the most common setting for gullies, but a substantial proportion are found on isolated knobs and hills and on valley walls (**table 1**). Pit wall gullies are common in the extreme south in MOC but were not seen in HRSC due to a lack of image coverage in this area. Gully length measurements (**fig 5**) from HRSC reveal that 1-2km gullies are most common but examples 2-3 times longer are also seen.

Discussion: While gullies show a preference for pole facing orientations, especially at mid latitudes, there is a SE skew in HRSC orientation data compared to MOC. This is almost certainly due to radiometric resolution and lighting conditions (many HRSC images were obtained when SW facing slopes are in deep shadow). However, the overall agreement in orientation and latitudinal distribution in the two datasets suggest the results are reliable.

The discovery that 10-16% of gullies occur on isolated knobs or hills is difficult to reconcile with a regional groundwater model of gully formation as it is unlikely that a sufficiently large aquifer to produce gullies (with lengths sometimes > 5km) could form within these isolated topographies. Instead, the obvious dependence of gully distribution and orientation with latitude suggest that insolation and climate play a controlling role in gully formation and that an atmospheric source for the water [e.g. 4] is more likely.

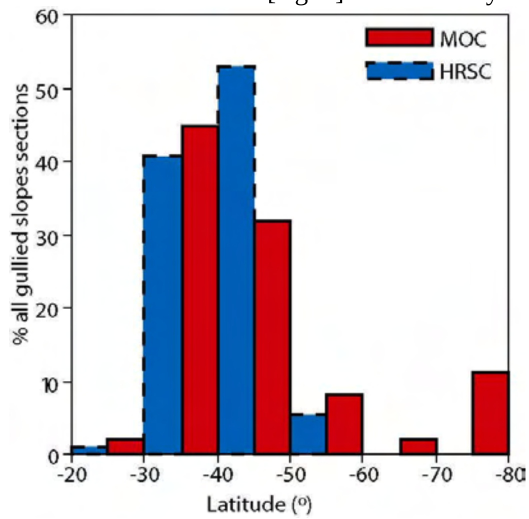

Fig.2. Latitudinal distribution of all gullied slopes.

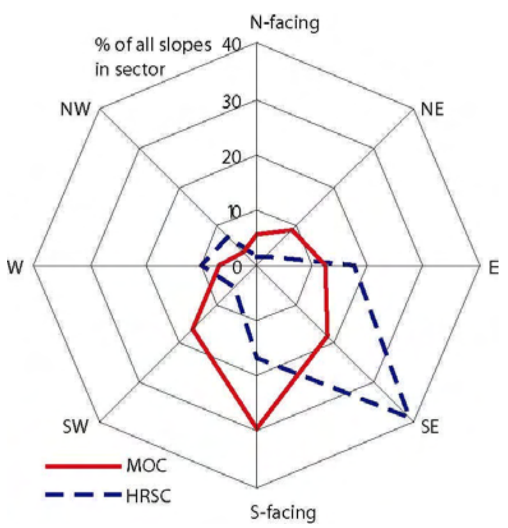

Fig. 3. Orientation of all gullied slopes

Fig. 3. Gully length from HRSC measurements only.

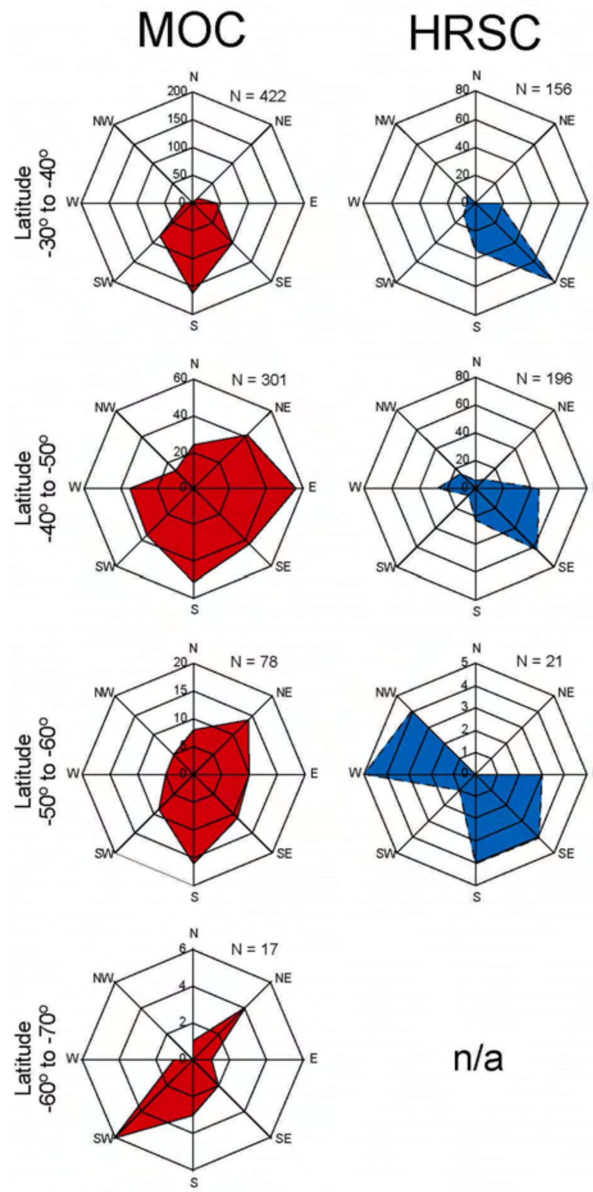

Fig.4. Orientation of all gullied slopes by latitude.

Context	% MOC	% HRSC
Impact craters	62	60
Knobs/hills	10	23
Valley walls	10	16
Pit walls	16	0

Table 1. Settings of gullied slopes as % of total.

References: [1] Malin, M.C. and Edgett, K.S. (2000) *Science*, *288*, 2330-2335 [2] Mellon, M.T., and Phillips, R.J. (2001) *J. Geophy. Res.*, *106* (E10), 23,165-23,180 [3] Gaidos, E. J. (2001) *Icarus*, *153*, 218-223 [4] Costard, F. et al. (2002) *Science*, *295*, 110-113 [5] Christensen, P. R. (2003) *Nature*, *422*, 45-48. [6]